Precipitation and Latent Heating in Tropical Easterly Waves

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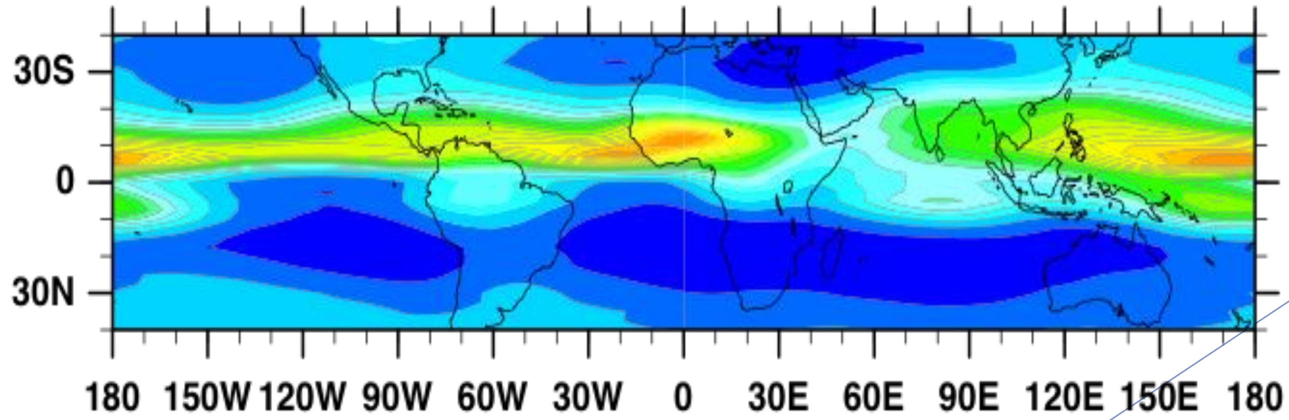
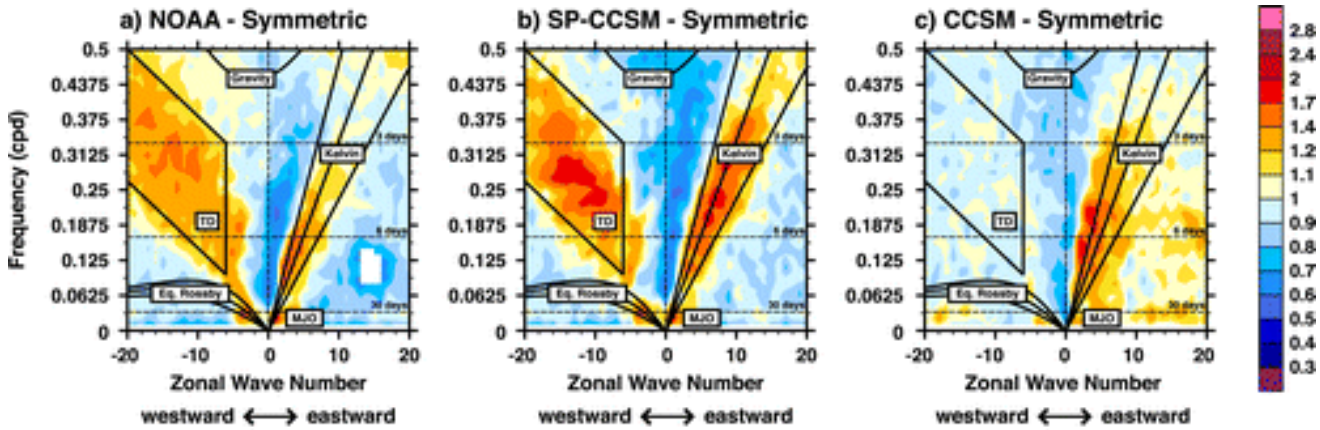
Tropical Easterly Waves

- Wavelengths 2000-4000 km
- Periods 2-10 days
- Occur tropics wide
- Impact and are impacted by convection and precipitation
- African Easterly Waves most studied (but not fully understood)!



Easterly Wave Filtered Outgoing Longwave Radiation (McCrary et al. 2014)

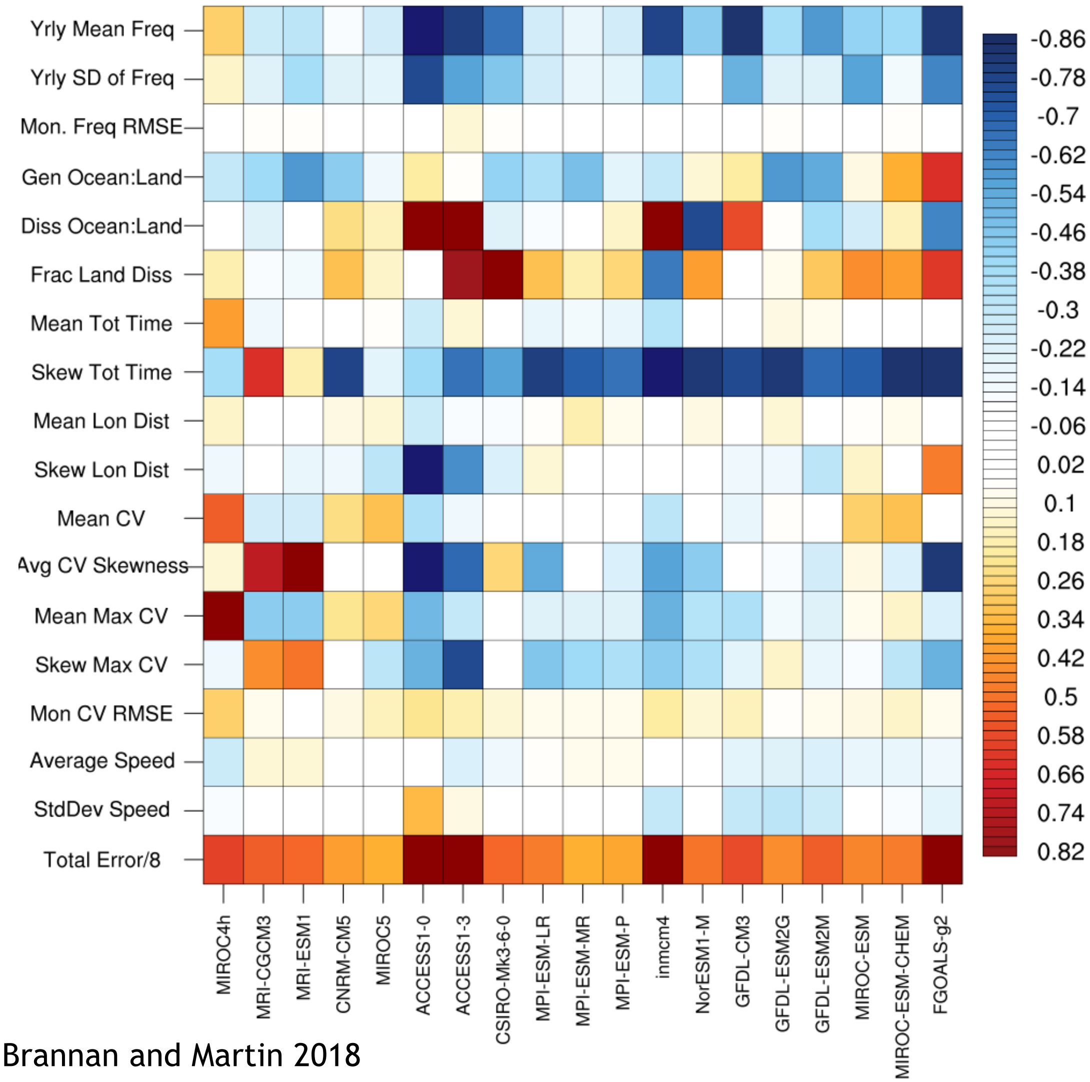
Climate Model Representation of TEWs



- Wheeler and Kiladis diagrams of OLR
- Adding super parameterization (SP) improved simulation of TEWs in this model
- Wide variability between climate models

Climate Model Representation of African Easterly Waves

Hypothesize that the interaction between moist convection and TEWs is a major source of weather and climate model bias through biases in latent heating.



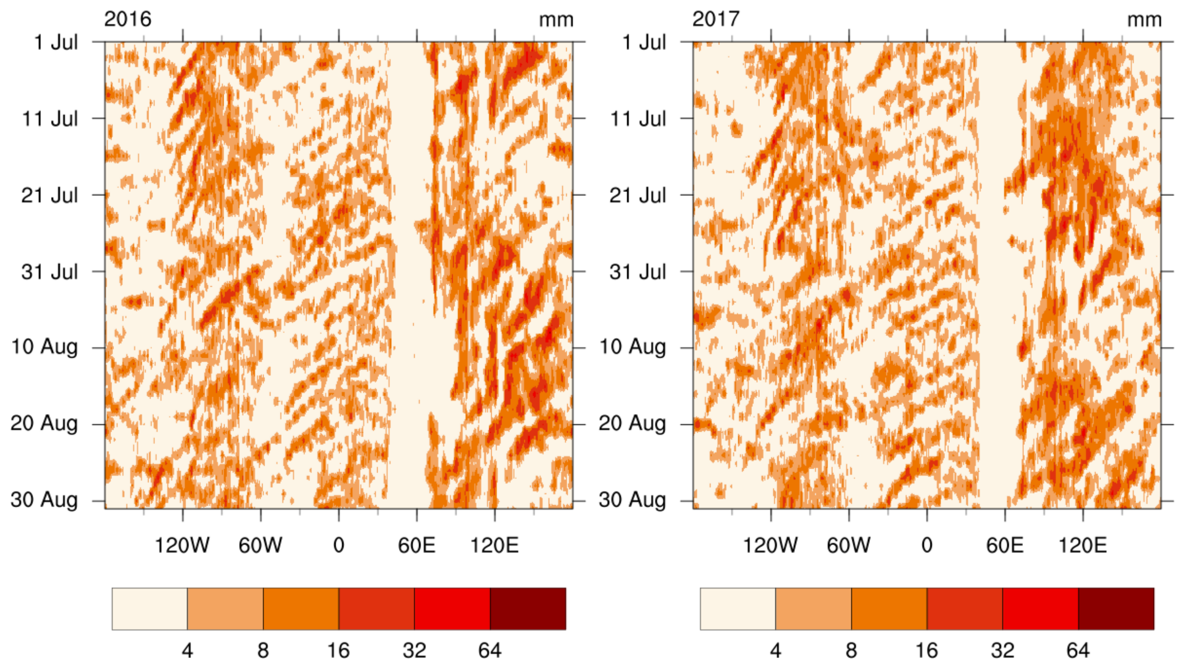
Brannan and Martin 2018

Goals & Objectives

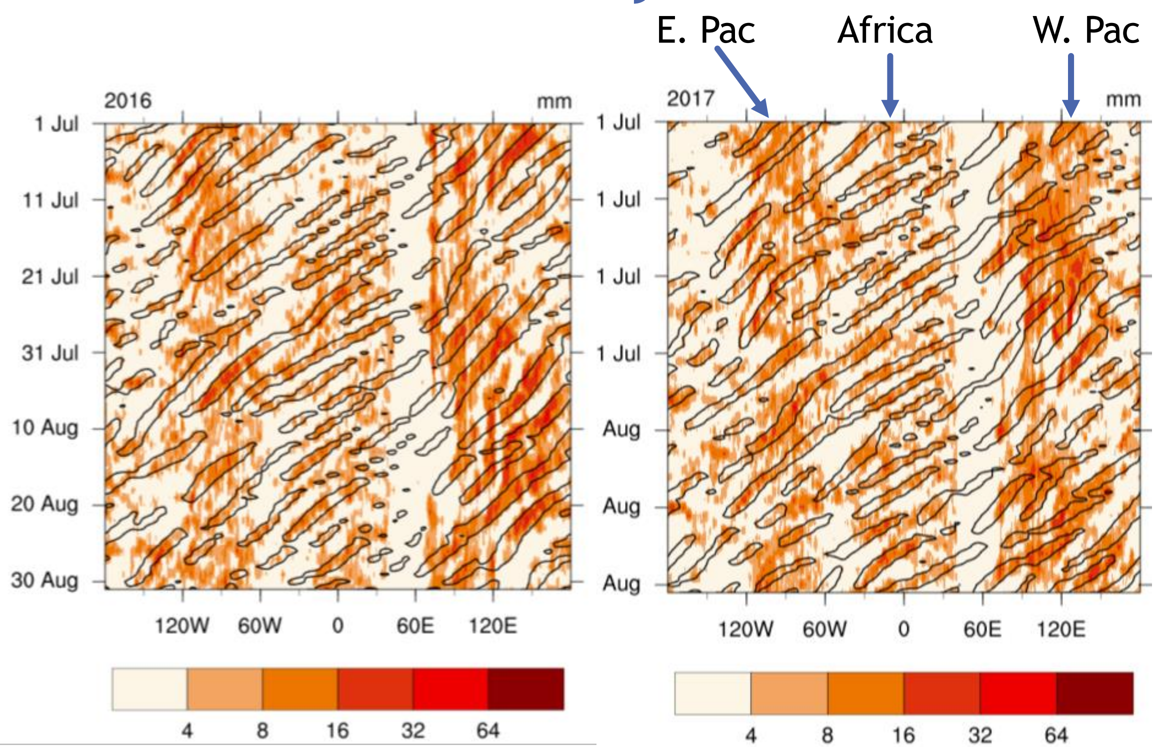
- **The goal of this project is to understand precipitation and heating during the lifecycle of tropical easterly waves (TEWs) to improve model biases in the representation of these waves.**

- Objective 1: Determine and analyze the amount and structure of convection and precipitation over the lifecycle of TEWs across the tropics.
- Objective 2: Examine the latent heating profiles within TEWs and their relationship with TEW intensity and evolution.
- Objective 3: Diagnose variability in TEW precipitation processes spatially (region-to-region) and temporally (year-to-year).
- Objective 4: Identify and understand discrepancies in latent heating profiles of TEWs in MERRA-2 reanalysis and the NASA-GISS climate model.

TEWs in GPM Daily Data

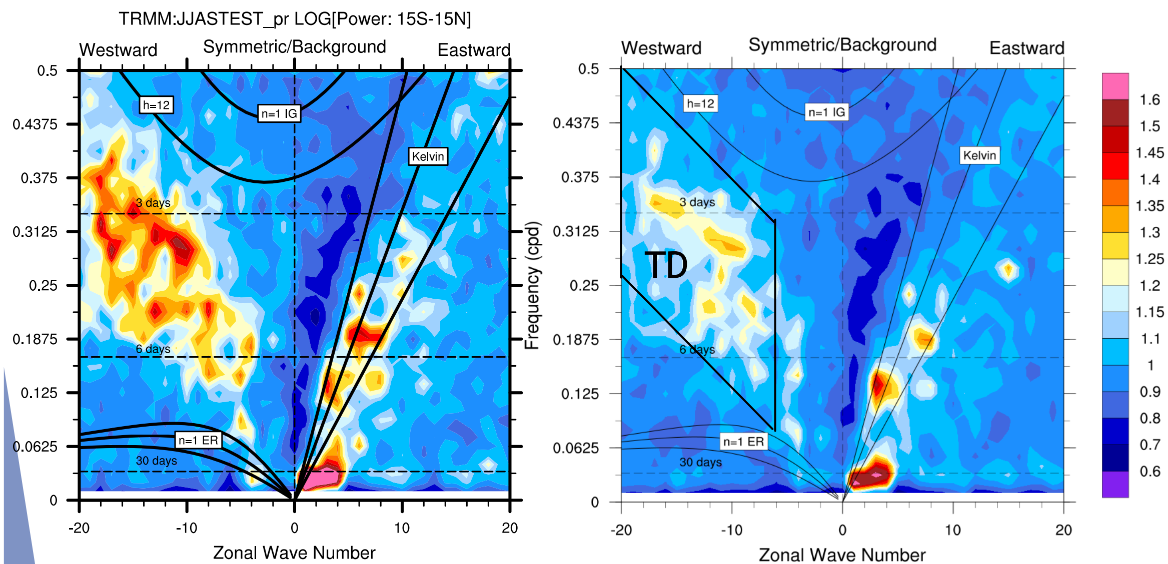


TEWs in GPM Daily Data



- Period:2-10 days
- Wavenumber: 6-15 (easterly)

TEWs in IMERG: Spectra

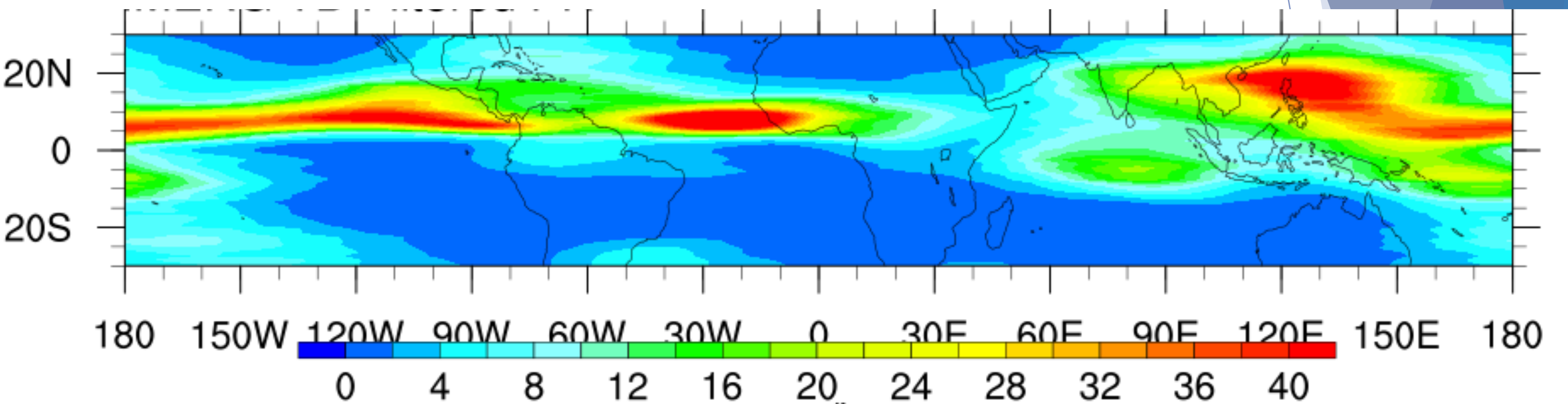


TMPA
3B42
1998-2014

IMERG
v6
2001-2018

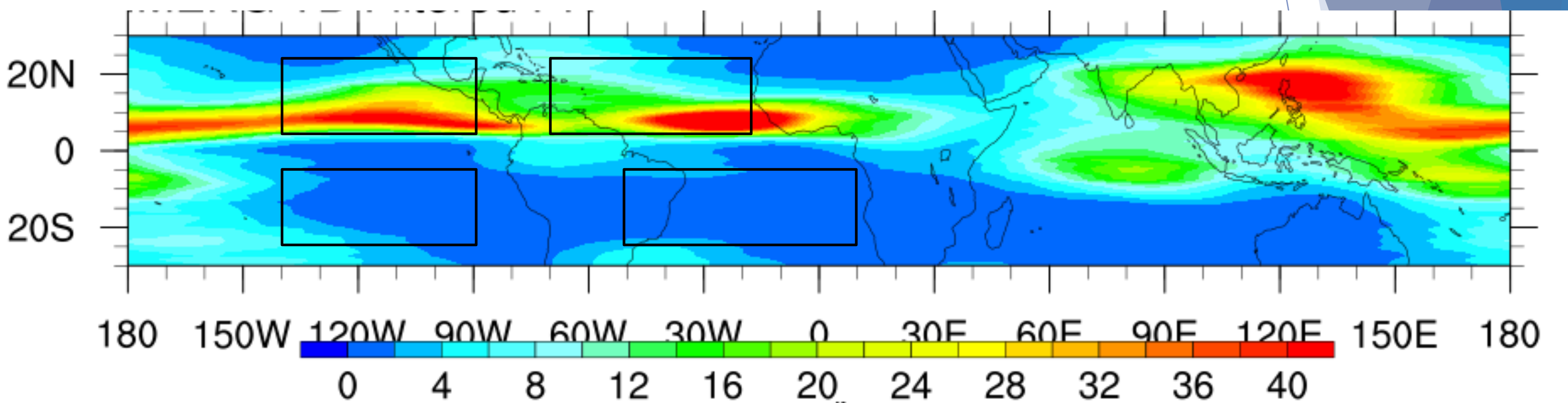
- Average JJAS Signal-to Noise Power Spectra for disturbances that are symmetric about the equator.
- IMERG: 3 hourly and 0.5°

GPM: Spatial Variability of TEWs



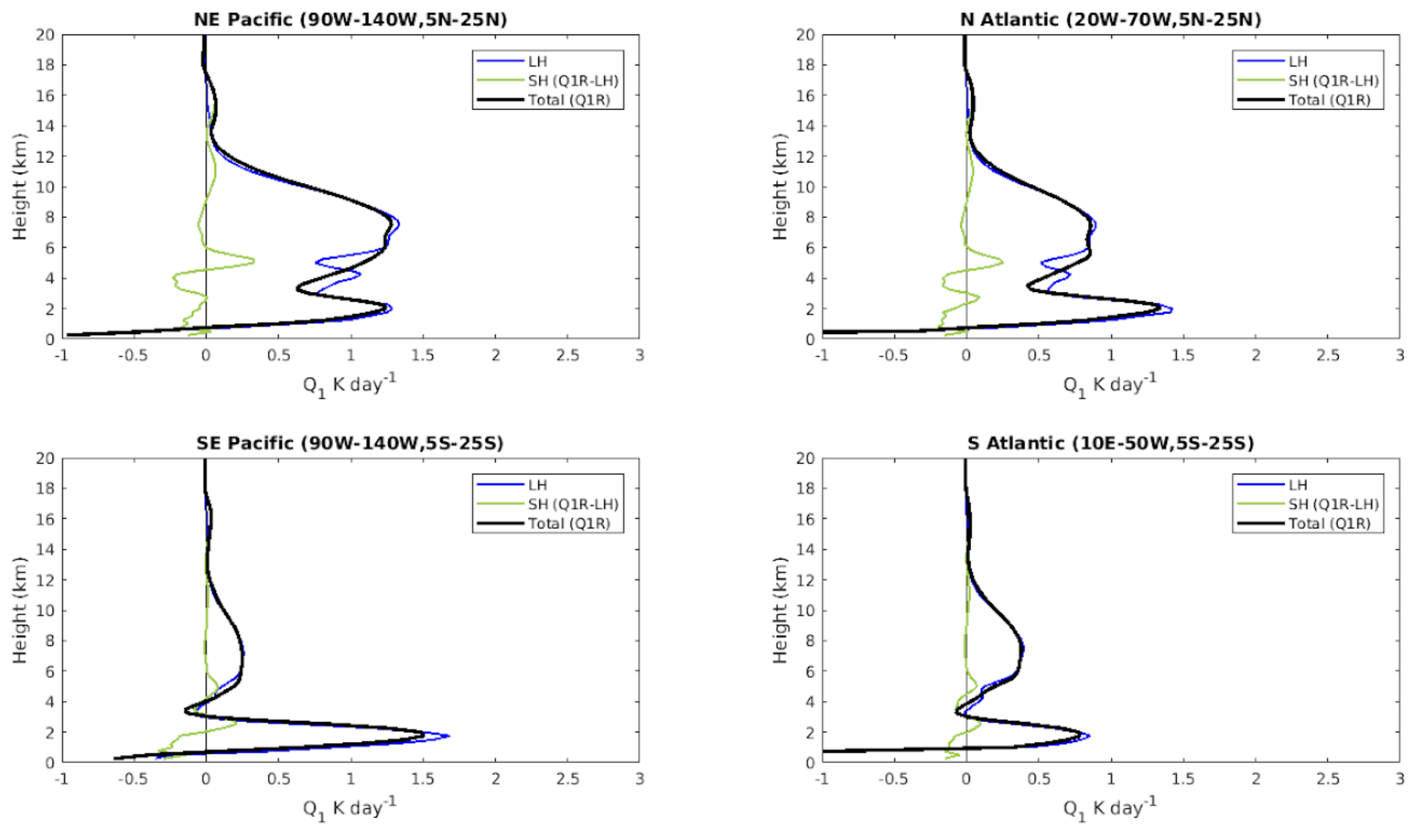
- JJAS mean variance of TD-filtered precipitation from IMERG.
- Unexpectedly high activity in in East Pacific

Heating Profiles (1998-2014)



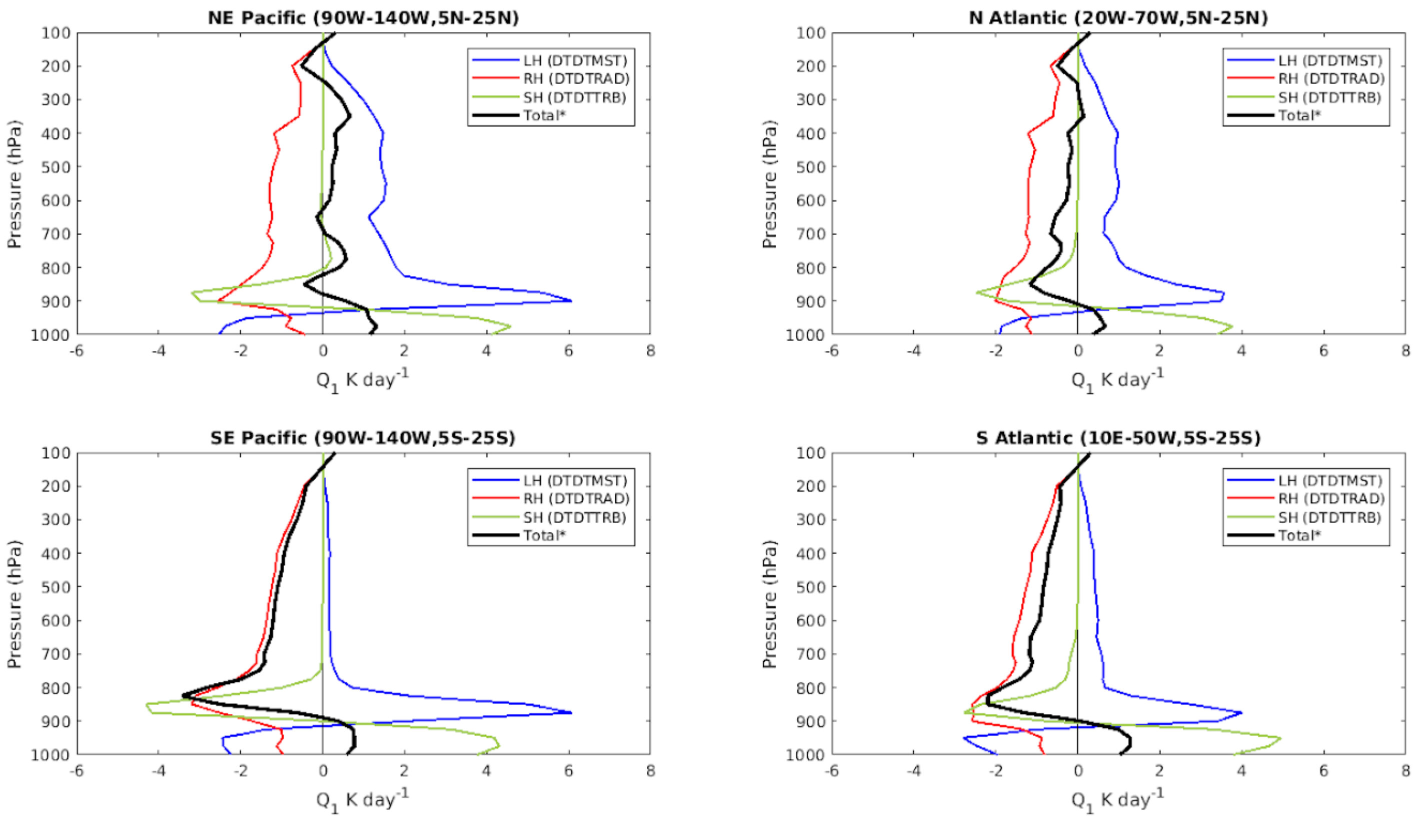
- NASA MERRA-2 Reanalysis Temperature Tendencies
- TRMM/GPM Spectral Latent Heating (3HSLH v6)
- Full year, monthly averaged data from 1998-2014

TRMM/GPM Spectral Latent Heating (3HSLH v7)



*Unconditional means; SLH algorithm does not include radiative heating; Q1R = (Q_1 - Q_R)

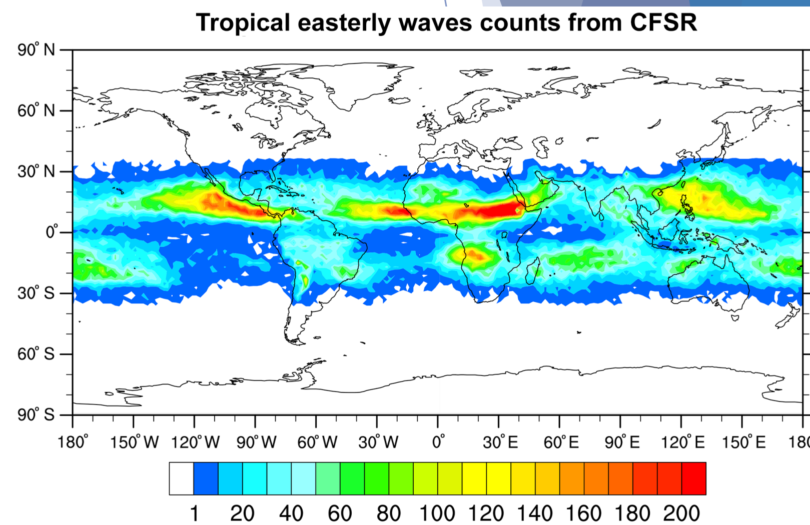
Heating Profiles – MERRA-2



*Total includes LH+RH+SH since DTDTTOT ("physics") in MERRA-2 includes frictional heating

Next Step: Tracking Individual Waves in MERRA-2

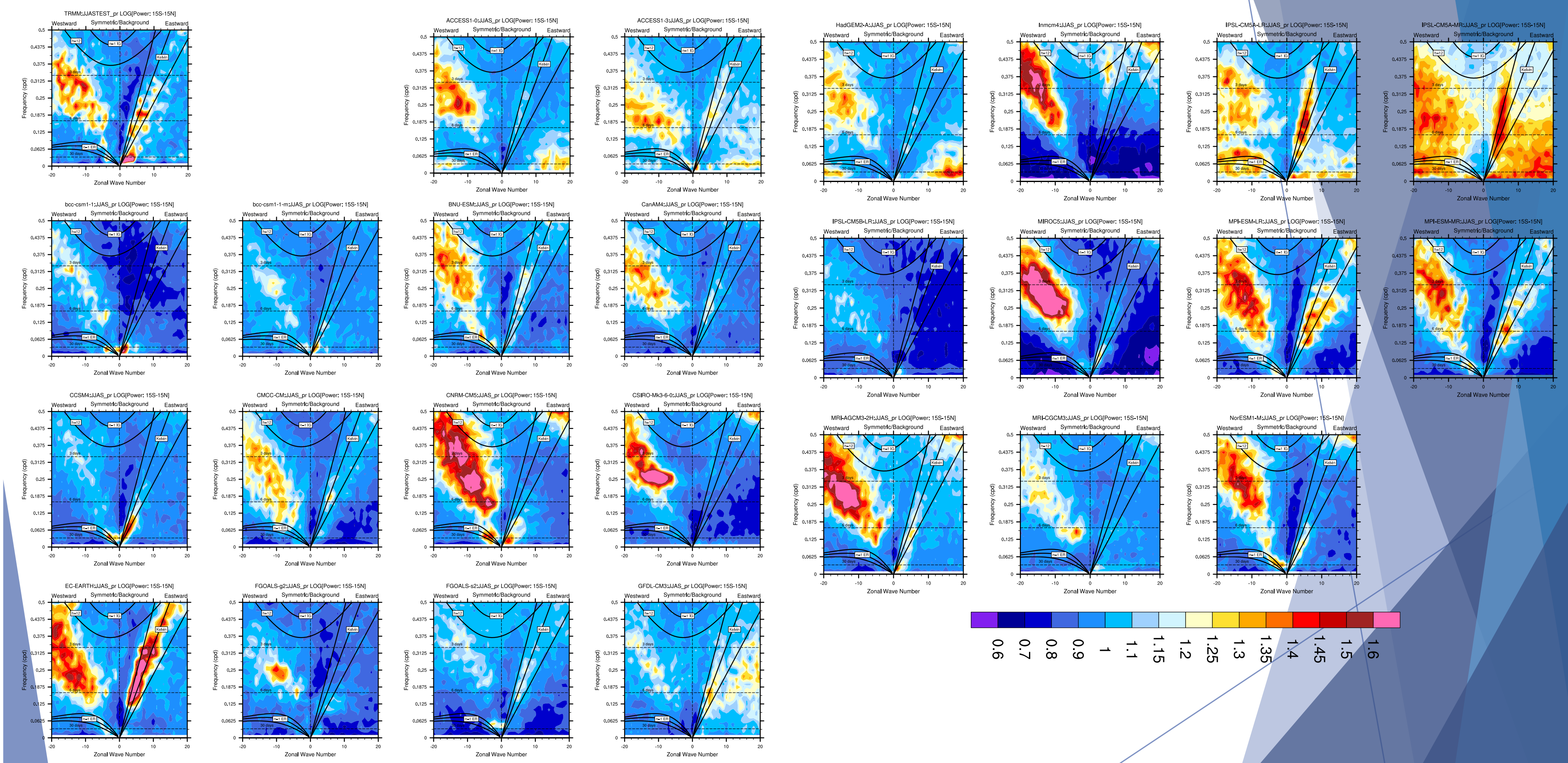
- TRACK
  - Objective feature tracking This method tracks curvature vorticity (Hodges 1995, 1999)
- TEMPEST Extremes
  - flexible, open-source, parallelized algorithm developed for detecting extremes in gridded climate data. (Ullrich and Zarzycki, 2017).
- Relative or Curvature Vorticity
  - Curvature vorticity identifies a change in wind direction over some horizontal distance and was shown by Berry et al. (2007) to be a useful diagnostic for distinguishing the trough of a wave from the background shear vorticity.
  - Enables dry and convective wave identification



TEW counts from CFSR (From Ullrich and Zarzycki (2017)

Summary

- TEWs important for convection and precipitation
- They occur globally but are studied little outside the Atlantic
- Understand spatial, temporal, and lifecycle variability of precipitation and heating associated with TEWs
- TEWs exist in GPM precipitation spectra
  - Weaker signal than expected
  - Maxima in Atlantic, E. Pac, and broad peak in W. Pac
- Climatological latent heating magnitude is significantly less in TRMM/GPM observations than reanalysis
- TRMM/GPM observed heating is more top-heavy in all domains (stratiform rain fraction)
- Upcoming year: track individual waves and associate with precipitation and heating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ACCESS1-0:JJAS_pr LOG[Power: 15S-15N]
ACCESS1-3:JJAS_pr LOG[Power: 15S-15N]
HadGEM2-A:JJAS_pr LOG[Power: 15S-15N]
Inmcm4:JJAS_pr LOG[Power: 15S-15N]
IPSL-CM5A-LR:JJAS_pr LOG[Power: 15S-15N]
IPSL-CM5A-MR:JJAS_pr LOG[Power: 15S-15N]
bcc-csm1-1:JJAS_pr LOG[Power: 15S-15N]
bcc-csm1-1-m:JJAS_pr LOG[Power: 15S-15N]
BNU-ESM:JJAS_pr LOG[Power: 15S-15N]
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IPSL-CM5B-LR:JJAS_pr LOG[Power: 15S-15N]
MIROC5:JJAS_pr LOG[Power: 15S-15N]
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NorESM1-M:JJAS_pr LOG[Power: 15S-15N]
EC-EARTH:JJAS_pr LOG[Power: 15S-15N]
FGOALS-g2:JJAS_pr LOG[Power: 15S-15N]
FGOALS-s2:JJAS_pr LOG[Power: 15S-15N]
GFDL-CM3:JJAS_pr LOG[Power: 15S-15N]
Westward
Symmetric/Background
Eastward
Frequency (cpd)
Zonal Wave Number
0.6
0.7
0.8
0.9
1
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
1.6